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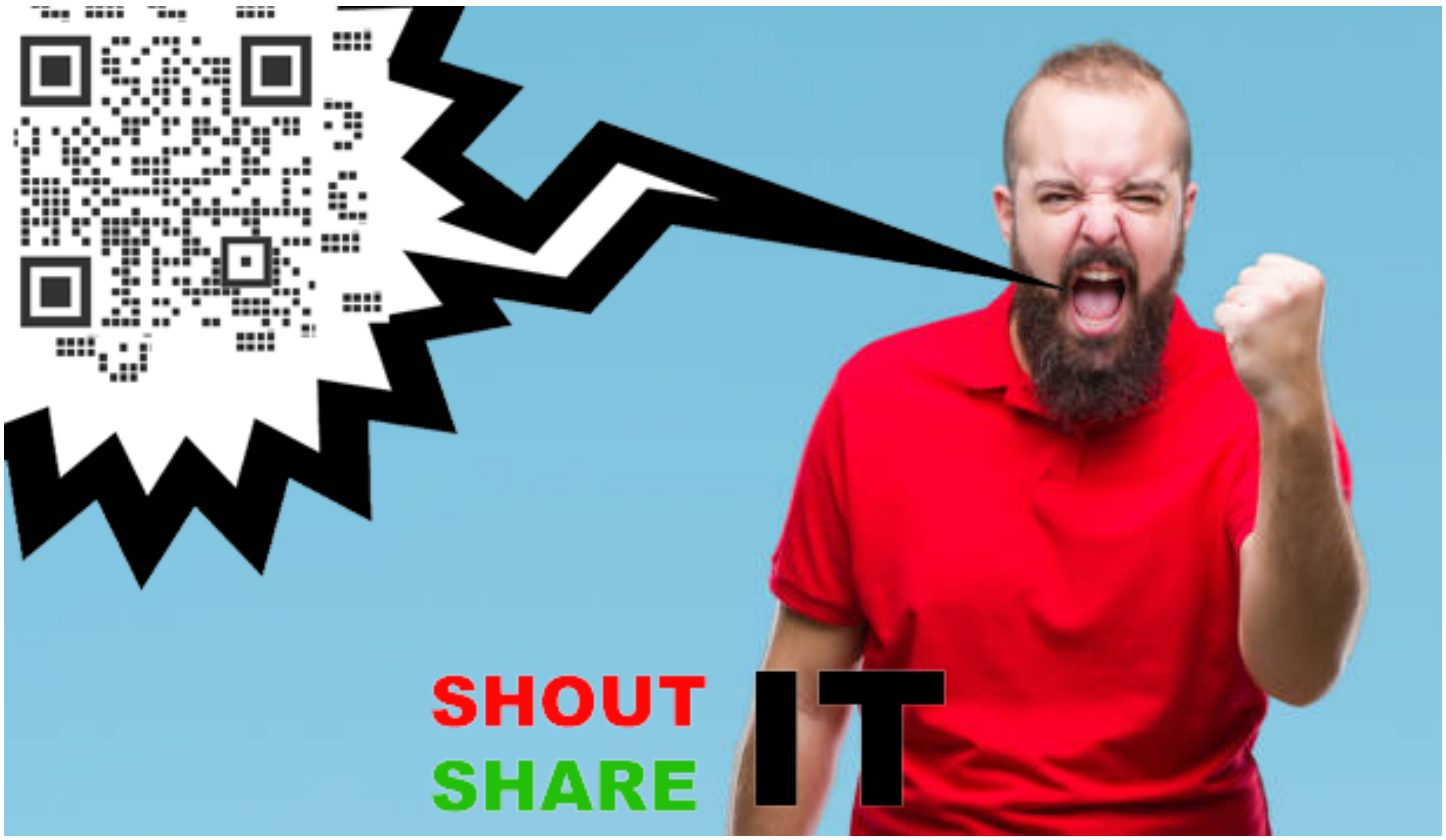
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EVOLUTION

A JOURNAL OF NATURE

Courtesy American Museum of Natural History

HANDS OF COUSINS — MAN AND GORILLA

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EVOLUTION
A Journal of Nature
For popular education in natural science to combat bigotry and superstition and develop the open mind

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Evolution's staff of Contributing Editors is strengthened through two additional science writers: Dr. Pauline H. Dederer is Professor of Zoology at Connecticut College for Women and knows how to make Natural Science interesting to beginners. Dr. Carroll Lane Fenton has taught at the Universities of Cincinnati and Buffalo, has done field work in Paleontology since 1908, is the author of 25 of the Little Blue Books and of "Studies of Evolution in the Genus Spirifer," just published.

FRIENDS OF SCIENCE TEACHING should not be misled because at the moment Fundamentalism isn't making much public noise. It is very active with a preparatory campaign of "education." Hardly an issue of the numerous fundamentalist journals appears without articles attacking the teaching of evolution, purporting to disprove evolution on scientific grounds or arousing the passions of readers by blaming evolution for crime waves, wars, "flaming youth," "degeneracy of civilization," etc. Of course, parents believing this nonsense become convinced that the eternal welfare of their children is involved.

The avowed purpose of fundamentalists is to force the people to vote on this question in every State that has the Initiative Law, and finally to control the nation. By popular vote they could probably carry most of the States. If you wait until they have put the question on the ballot, it is already too late. Then passion and prejudice will not even hear the voice of reason. The time to meet the situation is NOW.

And the way to meet it is Popular Education in Natural Science. It is possible to give the people at least enough understanding so that they will realize how foolish it is to try to settle such questions by majority vote at the ballot box. YOUR help, the help of every friend of science teaching, is needed in this great work.

OPPOSITION TO EVOLUTION teaching is not confined to "backwoods," as some professors secure in the serenity of their scholastic halls, seem to think. Because the fact of evolution is taken for granted in all University circles is no sign that it is accepted everywhere.

Right in Boston, in the very shadow of Harvard, the influence of superstitious bigotry is so strong in the school administration that biology teachers in the Boston High Schools are not free to explain evolution to their students. In thousands of school districts all over the country the boards are so reactionary that, for the sake of their positions, teachers leave the subject of evolution alone.

THE GREATEST SCIENCE GATHERING

The American Association for the Advancement of Science, with fifteen sections and twenty-five scientific societies, will meet in Pasadena, Cal., from June 15 to 20.

Although most of this country's leading scientists are among the 19,000 members of this Association it also invites to membership all laymen interested in science, and many of the convention sessions are open to the public. Readers of Evolution will certainly find them interesting.

Registration is at Throop Hall. Fee $2. for non-members.

Reception, 2 P. M. Monday, June 15, at Huntington Library and Art Gallery. Five evenings, Public Lectures at the Greek Theatre in Griffith Park. The day-time scientific sessions are at the California Institute of Technology. There will be a series of symposiums, the first on "The Antiquity of Man."

Dr. Franz Boas of Columbia University, President of the American Association for the Advancement of Science, and Dr. Thomas Hunt Morgan of the California Institute of Technology, the Retiring President, will both be present.

More detailed announcements may be secured by addressing Harry H. Main, Los Angeles Chamber of Commerce.

RE-INFORCEMENTS WELCOME

The irregular appearance of Evolution the last year tells you more eloquently than anything we could write what our situation is. We have over 5,000 paid subscribers. But to "break even" we must have at least 10,000. In the meantime we must raise extra funds to publish and make the necessary educational campaigns. Nowadays this is somewhat difficult. If *you* can send re-inforcements, do so now, specifying whether for Founders Fund or for Library Subscriptions.

HUXLEY ON EDUCATION

"That man, I think, has had a liberal education, who has been so trained in youth that his body is the ready servant of his will, and does with ease and pleasure all the work that, as a mechanism, it is capable of; whose intellect is a clear, cold, logic engine with all parts at equal strength, and in smooth working order; ready, like a steam engine, to be turned to any kind of work, and spin the gossamers as well as forge the anchors of the mind; whose mind is stored with a knowledge of the great and fundamental truths of Nature and of the laws of her operations; and who, no stunted ascetic, is full of life and fire, but whose passions are trained to come to heel by a vigorous will, the servant of a tender conscience; who has learned to love all beauty, whether of Nature or of art, to hate all vileness, and to respect others as himself."

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In the Land of the Gorilla

By WILLIAM KING GREGORY

Professor of Vertebrate Paleontology, Columbia University; Curator of Dept of Comparative Anatomy, American Museum of Natural History

THE African Anatomical Expedition of Columbia University and the American Museum of Natural History was initiated by Dr. Dudley J. Morton, Associate Professor of Anatomy in the College of Physicians and Surgeons.

For some time past Professor Osborn and the writer had been engaged in a lively but always friendly scientific debate bearing on the relative nearness or remoteness of man's relationships to the existing anthropoid ape stock. Professor Morton, Professor McGregor and others also had taken part in the discussion, but all recognized the need for more comprehensive comparative studies on the anatomy of the anthropoid apes, especially of fully adult gorillas. Hundreds of gorilla skulls and skins have been described by specialists, but there is an almost complete dearth of well preserved adult specimens in the anatomical laboratories of the world.

An expedition to secure this material would give to several specialists whose interest centered more or less upon the grand problem of man's origin, an exceptional opportunity to study living anthropoid apes in their natural environment, and to bring back to their laboratories and classrooms something of the teeming pageant of Africa.

The leader of the expedition was Henry C. Raven, Associate Curator of the Department of Comparative Anatomy in the American Museum of Natural History and Lecturer in Zoology in Columbia University. Mr. Raven is well known in museum circles for his previous zoological expeditions in Borneo, Celebes, Australia, Greenland and Africa.

Professor J. H. McGregor, of the Department of Zoology, who may be called the senior naturalist of the expedition, is well known for his carefully considered reconstructions of the external appearance of the extinct races of man.

Associate Professor E. T. Engle of the Department of Anatomy, College of Physicians and Surgeons, is an authority on the anatomy and physiology of the mammalian reproductive system.

The present writer, besides sharing in the interests of his colleagues, is especially concerned with problems relating to the earlier history of the anthropoids: How are they related to the fossil anthropoids whose jaws and teeth have been found in various parts of Europe, Asia and Africa? How did they first get into Africa?

This expedition, which left New York in May, 1929, is only now completing its field work. Its launching encountered serious initial difficulties. Owing to the praiseworthy policy of the Belgian government to protect their gorillas, our expedition only after the greatest efforts received permits to kill two adult mountain gorillas in some region outside the Parc National Albert.

We decided to search for our gorillas in the mountains southwest of Lake Kivu. If the hunter can get near enough it is comparatively easy to kill a gorilla, even in the almost impenetrable thickets in which they are often found. A dead gorilla can easily be skinned with the help of natives and his dismembered carcass can be carried back to camp on poles or on the heads of porters. But we were not after gorilla skins or skeletons; we wanted only the complete animal. Thus it eventually proved necessary to carry a dead gorilla weighing about four hundred pounds down a very steep, rough mountain side through many miles of tangled jungle. This was successfully done by Mr. Raven and his porters after he had stopped a charge by an infuriated male gorilla within fifteen feet of his rifle. Raven found, in fact, that this gorilla resented being followed and did not hesitate to rush at the intruder, who fortunately for himself was quick and sure with his rifle. He was thus able to shoot the animal through the head, which was the only way of avoiding injury to the main blood-vessels of the body.

At the base camp, after tying off the arteries of the head, Raven was able to inject the rest of the body with preservative fluid. This fluid, contained in a metal tank fastened on top of a stout pole, came down a long rubber tube and was forced by gravity into the great artery on the inner side of the thigh, whence it quickly penetrated to all parts of the body. The head was then separately injected through the carotid artery. This well preserved specimen was subsequently shipped to New York and is still in fine condition. Its anatomy is now being studied by several specialists.

Courtesy American Museum of Natural History

One of two gorillas, captured in the Kivu, photographed where he fell, after brush and vines had been cleared away. Left, Dr. McGregor; right, Mr. Raven; standing, Dr. Gregory.

The second gorilla, also a male, was secured by Raven near our camp in the same general region (southwest of Lake Kivu). It also weighed about four hundred pounds and was eight feet, six inches across the tips of its outstretched hands. Its digestive tract contained many bucketsful of green vegetable matter, as the gorilla is exclusively a vegetarian. The vermiform appendix was very

*EXCERPTS FROM MARCH, 1931, COLUMBIA UNIVERSITY QUARTERLY.

human looking. Carefully prepared molds of the head and bust, hands and feet of this animal were made by Professor McGregor in the field, while its finger and toe prints were recorded by Professor Engle and the writer.

While in this mountain-forest region the members of the expedition made many excursions into the jungle and forest in the endeavor to get near enough to see the gorillas. Native paths traverse the forest in various directions but the gorillas in this neighborhood are as a rule exceedingly wary and difficult to approach. Nevertheless the members of the party enjoyed a number of opportunities of seeing them, although the photographic conditions proved very unsatisfactory. Late one afternoon, for example, we saw and heard them making their beds for the night. Some made a rough oval depression in the thicket on the ground. Others, including one or more adults, slowly climbed the tangle of vines and branches and settled down in the large "nests" in the trees. The next morning our efforts to secure motion or still pictures of the same party of gorillas were defeated by their persistent hiding in the near-by thicket, although we could catch glimpses of one of them beating its chest.

After a short side trip into the forest north of Stanleyville, in the heart of the Belgian Congo, the expedition proceeded down the river and by steamer up the west coast to Douala in French Cameroon, thence inland into the rough, hilly country.

In this region the gorillas live in small bands, roaming at will wherever the forests have not yet been destroyed and sometimes invading abandoned banana fields. As we did not approve of organized drives, which have often resulted in the slaughter of a number of gorillas by the natives, Mr. Raven preferred to rely solely upon his own efforts supplemented by those of a few native hunters, who wandered with him in the forest in search of the elusive gorillas. His task again proved very difficult, partly on account of the wandering habits of gorillas and the difficulty of locating them in hundreds of miles of forest, partly because it was necessary to get close enough to shoot the animal through the head, for reasons already explained. In the dry season the animals heard the crackling of leaves long before the hunter could get near and when they started off they left no visible track on account of the padded surface of their soles. In the wet season the country is inundated with an enormous rainfall, which changes the streams into torrents and makes traveling very difficult. Thus it happened that a collector of long experience and exceptional ability was baffled month after month in his unceasing efforts to accomplish the objects of the expedition. In the end, however, his patience and skill won through and the anatomists of the world will be indebted to him for one of the rarest prizes that could come into the laboratories, the well preserved bodies of several full-grown gorillas.

That these gorillas may have found their way into the Congo forest from the northeast is suggested by the following facts: first, the jaws and teeth of fossil anthropoid apes have been found in Spain, France, Austria, Egypt, India, in formations of late Tertiary age; secondly, some of these fossil types (of species named *Dryopithecus fontani* and *Dryopithecus rhenanus*) show certain significant resemblances on the one hand to the teeth of the gorilla and on the other to those of the chimpanzee; thirdly, many other modern African mammals appear to be descended from, or closely related to, extinct species known from fossil bones found in Tertiary deposits of southern Europe may be found today in Africa; fourthly, it is known from fossil remains that in Miocene times various mammals apparently of European or Asiatic derivation lived in East Africa. But although the African anthropoid apes, along with other mammals, seem to have been derived from Europe or Asia, we do not know why the lowland or West African gorilla are now found only on opposite sides of the Congo forest, or why there is today a long stretch of forest territory between them which is occupied by the chimpanzees but not by gorillas.

In conclusion, it is much too early to summarize the ultimate scientific results of the expedition. The material which is now available is being studied in connection with a general review of the comparative anatomy of the higher primates. Later, from all the available data we shall attempt to compile a revised and fairly compact account of the chief resemblances and differences between the gorilla and other primates, including man. It may reasonably be hoped that this analysis may contribute somewhat to a more precise evaluation of conflicting theories as to the time when, and the place where, and perhaps some of the reasons why, man's ancestors became recognizably different from their anthropoid cousins; but as in the case of many another scientific inquiry, the unforseen results are just as likely to prove to be the most important.

Hunting the Gorilla

By HENRY C. RAVEN

Associate Curator, Comparative and Human Anatomy, American Museum

As soon as it was dawn we were up and shortly afterward set out to hunt. Four Batwa pygmies, professional hunters, accompanied me. It was delightful to go into the forest with these little people, who understood the forest, whose home it was. We first climbed up the moutain through a mass of cold, wet bracken, then descended into a ravine through virgin forest so dark that it seemed like twilight. After about a half-hour of walking, very difficult on account of the steep and slippery ground, we came upon gorilla tracks and saw the remains of chewed-up stems. About an hour from the time we began to follow the trail we were passing diagonally down a steep slope toward a tiny stream. Across the ravine sixty or seventy yards away, we saw the vegetation move and we caught glimpses of an animal between the branches. Then we must have been seen or heard, for there was a sudden short bark. We followed across the stream and up the steep slope, climbing with difficulty where the gorillas could pass with ease. It was much more difficult for me, with shoes, than for the barefooted, strong-toed, unclad natives, and still easier for gorillas with powerful bodies, short legs, and long arms. Man's long legs are suited to the erect posture and not well adapted for going through underbrush, where he must often be doubled up.

We were now getting close to the gorillas; we knew there

*EXCERPTS FROM MAY-JUNE, 1931, NATURAL HISTORY.

was not a large troop, perhaps only three or four, but there was one big male among them, as we knew from the tremendous power in the bark he had given. The pygmies were nervous, saying that he would rush at us. We had gone less than three hundred yards from the stream and were still going through dense underbrush when suddenly the rush materialized with a terrific roar and shriek. The pygmy that was crouched down ahead of me, cutting the vegetation, sprang

Courtesy American Museum of Natural History

Pigmy Hunters, who helped Mr. Raven hunt the gorillas, carrying spears and brush-hooks.

back and raised his spear, while I stood ready to fire. But the gorilla stopped short, and did not come into sight. We continued on the trail and in a short time he rushed at us again. This time he was directly at our left, not ahead of us. Here the forest was a little more open and we could see perhaps ten or fifteen yards, but still he did not come within sight though we could see the vegetation move.

Finally we started up the slope. One pygmy went ahead of me, holding in one hand his spear and in the other his little sickle. He passed beneath a fallen tree and I had just stooped under this tree when the gorilla, closer than any time before, gave a terrific roar. I was afraid I was going to be caught under the tree but I managed to step forward and raise myself. As I did so I could see the great bulk of the gorilla above me and coming straight at me. I fired at his head as I might have fired at a bird on the wing. The impact of the bullet knocked him down and I wheeled to the pygmies, yelling at them not to throw their spears. I feared they would spoil my specimen. But they in turn shouted at me, "Shoot! shoot!" The gorilla was not dead. When I looked around he was standing up like a man; it was plain to see that he was stunned. I fired again and he dropped lifeless exactly fifteen feet away.

This animal was the most magnificent I had ever seen, weighing 460 pounds. He was black and silver-gray, a powerful, courageous creature, determined to drive off intruders from his domain. Upon closer examination I found this giant primate as clean as could be. The long, shaggy hair on his head and arms was as if combed only five minutes before. The silver-gray hair on his back was short and rather stiff.

Then came the time for quick action, for the specimen must be embalmed within a few hours. It must be got on to the trail, the trail must be widened from a foot to ten feet up and down steep mountains for about twelve miles. I sent a note to my companions asking them to send more porters. While I examined the fallen gorilla, some of the pygmies were starting to make a bed or framework of sapling on which to carry him.

By afternoon we had the gorilla out on the trail where I could embalm him. We then wrapped him in a large canvas tarpaulin and made him more secure on the litter. I refused to leave him at night for fear a leopard or other animal might attempt to eat the flesh; so the natives made a little grass hut for me right there on the trail. More porters arrived the following morning and I detailed several to go ahead to widen the trail. The gorilla and litter together weighed more than six hundred pounds. However, the natives started off chanting and went along for some distance at fairly good speed. After getting my paraphernalia packed in the loads I followed and caught up with them as they were trying to get up a very steep incline, where there was scarcely any foothold among the rocks and mud. I had told them that we must reach camp by nightfall, but it was soon evident that this would be impossible. As a matter of fact, it took two and a half days, during which there were severe electric storms that the natives claimed were caused by my having killed the "king of the mountain forests." They said the same thing happened when someone killed a very large elephant. At night we simply had to sleep in the forest in whatever shelter we could make of leaves and branches but it was always wet and cold.

Many of the natives ran away as soon as it got dark and I never saw them again but as this was the main trail between Lake Kivu and Nakalongi, there were natives passing along at intervals, and some of these were persuaded to help carry the gorilla.

The second gorilla was secured only three hundred yards from our main camp six days later. All members of the expedition took part in the various details of preservation of the specimen. There was material to be preserved for histological purposes, casts to be made of the hand, foot, and head, detailed measurements to be taken, etc. When we considered that the embalming fluid had penetrated the body thoroughly, the animal was bandaged, wrapped in blankets, and sewed up in burlap bags, these in turn coated with paraffin wax, and the whole again rolled in heavy canvas tarpaulin. A litter was again used to carry this specimen from our camp about four miles, and it was then placed in a motor truck and taken to Uvira, where it was shipped by steamer across Lake Tanganyika, then by rail from Kigoma to the coast, and put on an ocean steamer for America.

Courtesy American Museum of Natural History

Carrying the Gorilla to camp, twelve miles over mountain trail.

How Evolution Works

By H. J. MULLER
Professor of Genetics, University of Texas

VIII. Multiplication and Selection: Turning Accident into Order

This article concludes the series. Previous chapters reviewed the various theories of the causes of evolution, proved the randomness of mutations, traced their origin to the genes, and told of X-ray experiments that increased the number of mutations 15,000 per cent, indicating short wave radiation as a natural cause of evolution. We'll send these chapters to any new subscriber upon request.

IT does, at first sight, seem incredible that all the marvelous organizations in the living things about us could have been put together by anything partaking of the nature of accident. But we must remember that it did not fall together all at once, and that it was all made possible by that almost magical property which life owes to the gene—the power of multiplication of mutated individuals.

For many millions of years, blind chemical forces must have acted and interacted in early times to build up ever different and more complicated organic compounds and systems of compounds. A turning-point was reached when from these shifting combinations those self-multiplying yet mutable materials which we call genes happened to become formed. From that time on the different genes, or the little systems of organic matter containing an association of genes, would necessarily enter into a destructive competition for multiplication against each other, until, step by step, through mutation, or the alteration of the gene, and heredity, or the multiplication of the gene, the complicared present day life became differentiated.

It will be worth our while now to examine more closely just how it is really the peculiar power of multiplication of mutant forms which turns this trick of converting accident into order, by making such very extraordinary combinations of accidents possible as could not otherwise occur. For some reason, this fundamental feature of the matter does not seem to have been fully realized.

In examining the process of evolution, let us be content at first to make our case a very simple one, and to proceed for a while in a very elementary fashion, in order to avoid confusion. Let us first see how just a simple combination of advantageous changes, or mutations, may be obtained in an organism. Suppose we start with some extremely simple organism, represented by the straight vertical line at the top of Diagram I. We will now allow it to reproduce, and allow enough time to elapse so that some mutations or other will have appeared in each of its descendants (they need not be regarded as first-generation offspring). In our diagram these descendants are shown as vertical lines placed in a horizontal row just below the vertical line representing the ancestral individual, their derivation from which is indicated by dotted connecting lines. We may suppose that multiplication has brought about the existence of seven of these descendants, each with a different "chance" mutation, indicated by a differently shaped spot, and lettered from a_1 to g_1. g_1 may be taken to represent the "good" mutation—the one of an advantageous nature, which is in the path of progress, that happened to occur amongst all the others of a disadvantageous or neutral kind. Now allow a similar length of time to elapse again, in which multiplication and chance mutations take place much as before. The individual with the "good" mutation, g_1, thus multiplies to form seven again, each carrying g_1 (*i.e., the multiplication has involved the variation itself*), but, in addition to g_1, each of the individuals carrying it now carries a second mutation, lettered from a_2 to g_2. Among these second mutations we may again suppose that only one of the seven, g_2, is "good," in the combination in which it occurs. Thus we get a combination, in one individual, of two good mutations, g_1 and g_2, which supposedly have properties that "fit well together," interacting so as to work out advantageously in combination.

Some or all of the other individuals of the previous generation, bearing mutations a_1 to f_1, may also have multiplied. Whether or not they did would not affect our desired result—the attainment of the g_1 g_2 combination—at all, provided only that the g_1 individual itself had been able to multiply and mutate as indicated. If all the individuals of the previous generation had multiplied to just the same extent as the one having g_1 did, there would obviously have been 7 x 7 or 7^2, or 49, individuals formed bearing some combination of mutations, and of these forty-nine different combinations just one would be the "good" combination—g_1 g_2. Accordingly, without any "natural selection," there would be one individual in forty-nine having the "good" combination. In still other words, the "chance" of the good combination being present in any particular one of these final individuals, in the absence of natural selection, would have been 1/49. It is to be further observed that, no matter how few or how many of the above forty-nine individuals were actually produced, the ancestors of the g_1 g_2 individual (namely, the g_1-bearing individual and its predecessor, the simple line) had multiplied at the rate required for doing their share in the production of these hypo-

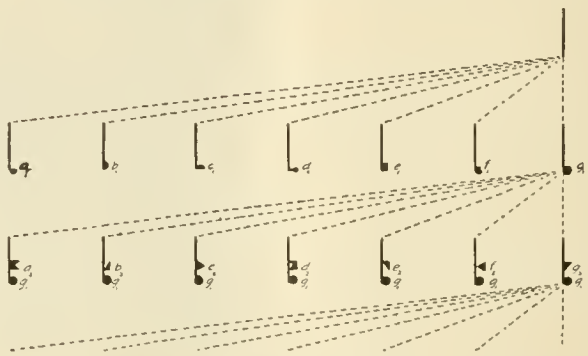

Diagram 1.
How Multiplication allows the origination of a beneficial combination of variations (g_1 g_2)

thetical forty-nine individuals.

We may now consider what would happen in the case of some kind of creatures, or objects, which did not have the power of multiplication, but which were otherwise similar to the organisms just discussed, and like them could mutate (or in this case we should simply say, "change"). We may suppose either that these beings produce just one offspring and then themselves die, or that they are potentially immortal and change directly from one form into another. In either case, if their "mutational" possibilities are the same as those of the multiplying organisms previously considered, then we should

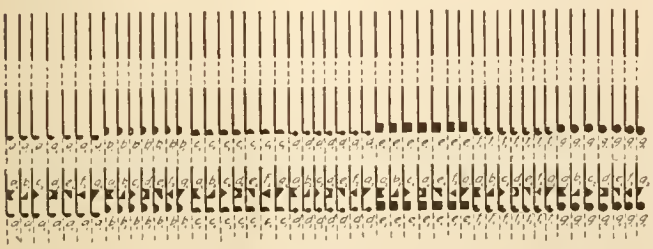

Diagram 2.
How a beneficial combination of variations (g_1 g_2) might arise without multiplication, and number required.

have to start with seven of them to get one having a change equivalent to g_1. But we should have to be provided with seven already bearing g_1 in order to obtain one having g_2. Since in the first place only one in seven come to have g_1 (or its equivalent), we should have to start with 7 x 7, or 7^2, or 49, in order to get the required seven having g_1 (or its equivalent) which would in turn yield the one finally having both g_1 and g_2 (or their equivalents). This is indicated in the diagram. (Here, for convenience in examining the diagram, similar types are grouped together, although chance would scatter them indiscriminately. Also, all forms of "equivalent" type are represented as though identical).

On comparing these non-multiplying objects with the multiplying ones we then see that, to get a given kind of combination by means of a given incidence of "mutation," we have to start with just as many, in the case of the non-multiplying objects, as, in the case of the others, would have been produced in the end by the entire process of multiplication, if all individuals had multiplied at the rate at which the selected individuals did. One out of this total number hence represents the "chance" that our desired combination could have come about purely fortuitously in any particular individual at the end of the given lapse of time, no matter whether the individuals were of the multiplying kind or not. By the laws of chance, if only a few times this total number are given, this combination, or one equivalent to it in "excellence," is practically certain, under the conditions postulated, to be present in one or more individuals.

Organisms, however, represent many more than two advantageous features in combination. By the same reasoning as the above, we may find the chance of obtaining a combination of three features—g_1 g_2 g_3. We may assume again that the g_3 change is in itself, at its time of occurrence, about as rare as either g_1 or g_2 alone was: namely, of the frequency of 1 in 7. It will then be seen that the g_1 g_2 individual must be allowed to go through a period (the third period) of mutation and of multiplication times 7, whereupon g_1 g_2 g_3 will arise. Further, it is evident that the rate of multiplication of the individuals in the line of descent that gave rise to the g_1 g_2 g_3-bearing individual was such as to have given rise to 7 x 7 x 7, or 7^3 or 343 individuals, after this lapse of time, if only all descendants of these ancestors had multiplied at the same rate as they themselves had. In the case of non-multiplying objects, it would have been necessary to *start* with 7^3 or 343 individuals, in order to get a corresponding result—an individual with a rare combination of three advantageous mutually adjusted characters, g_1 g_2 g_3. Generalizing, we may say that if the frequency of an advantageous mutation were 1 in r instead of 1 in 7, and the number of steps involved was s instead of 3, the corresponding total number of individuals would be r^s. All this is, in fact, only a simple application of a well-known and very elementary mathematical principle applying to the formation of random combinations in general.

It is not, however, until we apply this little formula to the natural conditions pertaining to our immediate problem that its full significance for us becomes clear. What shall we take as our "r" (the *rarity* of advantageous, or "organizational" mutations) and what as our "s" (the number of such advantageous mutational *steps*)?

Undoubtedly r changes its value radically at different stages in the evolutionary sequence, but it would seem quite conservative to represent r, in general, as being as small as 100. In other words, it seems likely that at least 100 mutations must usually occur before one occurs of such a special type that it could take part in the improvement of the life-organization. In flies (*Drosophila*) we find that there are something like ten times as many "lethal" and "semi-lethal" as ordinary visible mutations, and even among the "visibles," the vast majority reduce vitality or lessen the chances of survival in one or more ways. It is certain that not 1 in 100 detectable mutations is advantageous in flies; in fact, for all we know, the number may be more like 1 in 100,000.

In the case of s there are almost equally wide limits of uncertainty, but again we may arrive at a safe minimum figure. In flies I have shown that there are at least 1,500 different genes, and probably many times that number. There must then have been at least 1,500 different mutations to produce these genes from their predecessors. This figure, however, seems absurdly small in view of the great complication of a fly's anatomy, physiology and developmental processes. It is very likely, then, that there are many more genes than 1,500 and that each gene has had a history of numerous mutations, which step by step have differentiated it from one original type of gene. Considering too that man is certainly much more complicated than a fly, we might boldly guess that there may have been a million or more advantageous mutational steps in his ancestry (this would allow, say, 50,000 genes, in each of which, on the average, 20 mutational changes had occurred). Let us first, however, take s for man, at the undoubtedly far too low minimum value of 1,500, and r at 100.

Our total number r^s, thus becomes $(100)^{1500}$. That then is the minimum number of individuals we should have to start with, in the case of non-multiplying objects, to arrive, by "pure chance," at one having the complication and perfection of organization of a man. We shall examine later what the size of this number implies. It is also the minimum number which

the multiplication rate of the ancestors of man would have led to, if all the descendants of these ancestors had continued multiplying at this same rate, *i.e.*, without selection.

It might here be inquired whether such a rate of multiplication would have been possible or likely to occur in these ancestors, in the time during which life has existed on the earth. We know that life has been here for a period having an order of magnitude of something like a thousand million years, that is, a million millennia. If there were only 1,500 mutational steps in this time, that would make only one step in each 670,000 years. Our postulate, r—100, requires that an individual in the line of descent of man should multiply at least a hundredfold between each advantageous mutational step that became incorporated in the germ-plasm, and the next one. It is obvious that far more than this much multiplication could easily happen in 670,000 years. For it only takes seven doublings to make a hundredfold multiplication, and the slow-breeding modern European has been able to double his population merely in the space of the last century. The multiplying organisms, then, would have no difficulty in fulfilling these conditions.

Suppose, now, we try the more extreme figures, r—10,000 an s—1,000,000, so that r^s becomes $(10{,}000)^{1{,}000{,}000}$. To go through a million mutational steps in the course of a million millennia would require one mutation to become incorporated in each millennium, or thousand years. It would also be necessary for the selected type of mutant to multiply by 10,000 during this period of time, and meanwhile to undergo another mutation. There can be no reasonable doubt that a millennium is plenty long enough for many another mutation to occur, in all the descendant germ-plasms, but how about the large amount of multiplication here required? Most lower organisms go through a generation in not over a year's time, and are able, when given the opportunity, to multiply many fold in a single generation. If, however, we suppose that the "select" individuals, those with "good" mutations, only increase in numbers, on an average, by 2 per cent. in each generation, then, at a year to a generation, each such individual would increase from unity to nearly two hundred million in the course of a thousand years. This is far beyond our requirement of 10,000 times. Thus we see that the multiplying organism could probably do much better than accumulate 1,000,000 mutations during the time that life has already existed here, even though each mutation represented the selection of the best in 10,000. Allowance must, however, be made for the fact that accidental elimination wipes out the great majority of mutant genes within a few generations after their origination. That is, the process of "differential multiplication" or "selection" is very haphazard until a sizeable number of individuals with the mutant gene happens to become established.

There is another process which works in the opposite direction to the above, *i.e.*, which hastens the "establishment" of advantageous mutations in the selected lines of descent. This process is the formation of new combinations of genes occurring in sexual reproduction. For the sake of simplicity it has been ignored in this account. By its means it is made possible that various different advantageous mutant genes which have been multiplying simultaneously in parallel, in as many different (but partially overlapping) sections of a population, can be finally combined into one line of descent. Thus many more mutant genes can be accumulated into one (final) line of descent, in a given length of time, than if all the mutational events and selections had to occur successively in a single line. Owing to this factor, the number of mutational steps may well have been of a considerably higher order of magnitude than 1,000,000. Multiplication hence has probably afforded the opportunity of obtaining an individual that represents a chance of even less than one in $(10{,}000)^{1000000}$.

NATURAL SELECTION PRUNES LIFETREE

It should be noticed that, for the evolution of the multiplying organisms, the only two required conditions have been the occurrence of "chance" mutations (which need include only a very minute proportion of "good" ones), and the ability of the individuals carrying the "good" mutations to multiply to an extent which, within the limits of one generation, need be only extremely limited, but which, continued over a great lapse of time by something akin to a geometric progression, becomes prodigious indeed. In this process the role of "natural selection" consists in just this: that by the elimination of the "unfit" individuals, or the restriction of their numbers, room is made to *allow* the multiplication of the others at the rate required to provide the "chance" for the remarkable 1 in $(100)^{1500}$ or 1 in $(10{,}000)^{1{,}000{,}000}$ combination to appear. In other words, selection merely gives opportunity for the multiplication to proceed in the adaptive or better-organized lines at such a rate as would, if uniformly continued throughout, have given the total which automatically contains the "desired" combination. At the same time, we should not minimize the importance of natural selection in determining which individuals will be allowed to multiply, and, therefore, which of the myriads of possible directions evolution will be allowed to take. The old analogy to the process of pruning a tree is very pertinent in this connection.

If we imagine a world in which, through some sort of mitaculous intervention, the combinations which we now call the "unfit" are all allowed to persist and reproduce like the others, the evolution of the "fit" would nevertheless proceed much as in our own world, so long as they too were granted the opportunity to multiply as they do here. Thus "natural selection" would not be necessary for their production. But these "fit" or "well-organized" individuals, and lines of individuals, though in absolute numbers as numerous as here, would necessarily form but an infinitesimal fraction of all the unthinkably vast horde of other combinations that had come into existence simultaneously (just as in the hypothetical case of the non-multiplying beings, in which, if we started with this same final number to begin with, we would eventually find included among them by sheer accident creatures as complexly adapted as ourselves). The fact that the fit owed their existence to "chance" would then be obvious, owing to the relative smallness of the minority in which they existed. In our world, the misfits are largely nipped in the bud, and yet, in the sense just explained, we see that we too are really but the vanishingly small, viable, visible fraction of a stupendous ghostly army of potential creatures, involving a total of $(100)^{1500}$ to $(10{,}000)^{1{,}000{,}000}$, or more, possible combinations of misfits.

A little consideration may now be given to the size of this theoretical total number, to show that actually it would be quite impossible of physical attainment. Consequently, if there were no selective elimination, multiplication could not possibly have

gone on to anything like the required extent in the "good" lines. Likewise, if we had had to do with objects that could not multiply, there could not possibly have been anywhere near enough of them provided in the beginning to allow an organization comparable with that of a higher or even lower organism to be formed in any of them by mere "chance."

Even the admittedly far too low minimum figure, $(100)^{1500}$, is of staggeringly great dimensions. If there were this many beings actually produced, then, even if each being were as small as an electron, and all the beings were packed tight together, there would not be nearly enough room in the entire Einsteinian universe, packing them in a hundred times beyond the limits of the farthest visible stars and spiral nebulae, for even an insignificant tittle of them. If we allowed each of these packed "creatures" to go through its entire evolution, of 1,500 steps, in the millionth part of a second, and then substituted another "creature" for it and gave the latter a like chance, and so on for a quintillion years, we still should not have begun to make any appreciable impression on the above number. Neither should we if, in addition, each of these packed beings of electron size, present for each instant, were itself expanded into an entire Einsteinian universe, and each of these universes were then crammed with beings of electron size in its turn. In fact, we might continue thus expanding and subdividing worlds time and again without approaching sensibly close to the required figure.

Hence, in beings without the property of multiplication of variations, and its corollary, natural selection, any such incredible combination of accidents as ourselves would have been totally impossible of occurrence within the limits of practically any number of universes. We are thus really justified in feeling that we could not have fallen together by any accident of inanimate nature. But, given the power of multiplication of variations resident in "living" things, due to their genes, and all this is changed, and we are enabled to enjoy the benefits—such as they may be—of being the select of the select, such as it would have taken a surpassingly vast number of worlds to search through, before our match could be found anywhere by the ordinary processes of chance. In that way, I hope, the metaphysician may reach his "philosophical satisfaction" in the contemplation of his own frame and of the processes whereby it came into existence.

IX. The Task Ahead

The biologist is not satisfied to stop there, however. The real problems of the generation of new living things are only commencing to open up. The occurrence of variations, although "accidental" in the sense just explained, nevertheless is subject to a mechanism, our knowledge of which is as yet in its most elementary stage. Moreover, the biologist of broader view is not so well satisfied with his own frame. He knows that there never has been any one objective in the course of evolution, and that every creature, including man, is only on probation, and may give way before another in which a more advantageous succession of mutations happens to come along. The vast majority of species, in fact, have perished along the way, and only a relatively few survive, through change, to form the continuing threads of life that branch out again.

Man, however, is now the first creature in the world to have this advantage—he has reached some understanding of this process of evolution in which he has hitherto been caught and blown about, and with understanding there frequently comes some measure of control. He can now produce mutations for the first time, and I have no doubt he will soon experiment with this knowledge and in time by its means greatly improve and alter the forms and functionings of those domestic animals and plants which he has taken under his care. Look at the motley shapes of flies that have been made in the laboratory, and you may more readily appreciate the possibilities thus presented.

Despite these advantages, we are today almost as far as ever from producing to order the exact mutations which we want. Enough, for the plants and animals, simply to produce a great many mutations and then take our choice, as nature has done in a far slower and more halting fashion. But the research must go on. Man must eventually take his own fate into his own hands, biologically as well as otherwise, and not be content to remain, in his most essential respect the catspaw of natural forces, to be fashioned, played with and cast aside.

If we have had a billion years of evolution behind us, and have advanced from something like an ameba to something like a man, then, in the many millions of years which are still in store for our world, why may we not be able to make a further great advance, perhaps far greater even than this, because under our own increasingly intelligent guidance? At least, if we are men as we like to think of men, challenging all things, we must make the attempt, and die fighting if need be, with our eyes open.

Boners from Zoology Exams

A scientist discovered an old cork which he studied under the microscope.

Other discoveries were made of the proprieties of protoplasm.

A Hydra is an animal that looks like plant and grows on a stork.

The eggs and ova fuss, and produce a new individual.

Cuvier believed in a series of new creations and catechisms.

Apes and bamboos are arborial types of animals related to man.

Palœontologists have discovered fossils proving that there once existed an animal to which they have given the name asterisk, representing a link beween reptiles and birds.

Evolution is decent with modifications from pre-existing forms.

Pauline H. Dederer.

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Improving On Nature

By RALPH H. McKEE
Professor of Chemical Engineering, Columbia University

Eighty years ago New York was the leading lumber producing state in the Union and Pennsylvania was a close second. Today these states have almost forgotten that they once supplied the lumber or pulpwood for their own mills. They use about twenty-five times as much as they produce. About three years ago a commission was created by the New York State legislature to make a survey of the wood industry of the state. The commission found that, not only many mills using tinber directly, but other industries as well, have moved to locations nearer a source of wood supply. In fifteen years New York lost more than 1200 wood-using industrial plants.

States such as New York and Pennsylvania have four to five million acres each of abandoned lands, lands which contribute nothing to the prosperity and welfare of the state and which have become a liability instead of an asset. Many of these abandoned farms and cutover areas can be purchased for from three to eight dollars an acre. To what better purpose can this area be devoted than to plant it with trees?

Growing trees appears to be a problem requiring generations rather than years or decades to give results. However, using modern methods, this need not be so.

It is common knowledge that agricultural crops, such as wheat, oats, rice, corn, and so forth, have been improved by hybridization and selective breeding. Among tree crops hybridization has yielded conspicuous results in certain fruit and nut trees and in a few ornamental varieties. It is but logical to expect similar improvement in forest trees suitable for pulpwood and lumber if we applied the methods of hybridization.

Three sister hybrid poplar seedlings, all from the same catkin. Impossible to predict how crosses will turn out.

*Excerpt from Journal of Franklin Institute.

Hybridization is, as you know, the cross-breeding of individuals of different species. The loganberry is a cross between the antwerp raspberry and an ordinary blackberry. Hybrids, in general, grow faster, are freer from disease, than either of the parents. This is known to geneticists as "hybrid vigor." Unfortunately, hybrids do not breed true and are often sterile.

Hybridization, high in the tree, where flowers are.

In considering the improvement of trees for forest products the poplars seemed most promising. There were five hybrid poplars in existence so we knew that crosses could be obtained.

Our first problem was to locate the different varieties of poplars in this country. The largest collection was found to be at Highland Park in Rochester, the second largest at New York Botantical Garden. Other locations which furnished particular trees were Arnold Arboretum in Boston, and certain Long Island nurseries.

Before the flowers on the female trees opened, paper sacks were tied over the clusters to prevent normal pollination. Later, when the flowers opened. pollen was obtained from the flowers of the selected male tree. The pollen was taken at once to the female tree, and, by means of a wad of cotton, dusted over the female flowers. The sacks were immediately replaced to prevent normal pollination. After about two weeks the paper sacks were replaced by green cheesecloth sacks.. I might say that the only reason for staining the sacks green was to make them less conspicuous so that small boys would not throw stones at them.

Six weeks later when the seed had ripened, they were removed, taken to the laboratory where the cotton was carefully picked off and the seed planted in damp sand. Nature pro-

vides cotton so that the seed may be carried by the wind. Unfortunately this cotton is a handicap to growth and must be removed before the seeds are planted.

A large number of the hybrids were, of course, no more vigorous than the parents, but fortunately many grew with greater vigor than either parent. The trial was exceptionally successful. About fourteen thousand seedlings were grown and one hundred one new crosses were obtained.

There is little to indicate in advance of actual trial which crosses will yield offspring of noteworthy vigor. Rather more than one hundred of the best-growing hybrids were reserved and the remainder, nearly fourteen thousand, discarded. Each of these better seedlings was propagated by cutting it up into pieces ten or twelve inches long and stored for the winter. In the spring they were planted in the field nursery and by the next September each piece had become a six or seven foot tree.

Quick growth, however, was not the only factor to be considered in the final choice of hybrids. The concern which is going to invest in a reforestation project requires a good yield per acre and wood of a quality that will suit both the lumber man and the pulp manufacturer. Therefore, in selecting hybrids for propagation from the hundred we chose the stocky trees as against the slender ones of the same height, for the stocky would produce the greatest yield per acre. The shape of the tree was also important. A tree which is vertical and has few branches is to be preferred over one that is crooked and has heavy branches. Branches mean a distribution of the total wood in the tree and many knots—a source of trouble to the lumber man and pulp manufacturer alike.

In order to determine the quality of the wood, fibre studies were made and we found, as expected, that the length of the fibre varied in different hybrids. As longer fibre gives better paper and stronger lumber, we wanted to propagate the best quality possible. We were much pleased to find that fibre length and speed of growth were correlated. Thus, the fastest growing hybrids were those with the longest fibre.

Resistance to disease is also desirable and some of the hybrids were tested for common forest tree diseases. The result showed that many of the more vigorous hybrids were quite resistant to the more common poplar diseases.

The common wild poplars, *P. tremuloides* and *P. grandidentata,* from which much of the book and magazine paper is made, were compared with the hybrids. The studies disclosed that the speed of growth, that is, the weight of wood produced, of the new hybrids is from ten to fourteen times as much per year as the wild poplars growing under similar conditions.

After a tract of land is cut over it is customary to let the saplings that remain grow to trees. Such natural reforestation, as it is called, yields about six cords of useful wood per acre in sixty years, that is, an average of two hundred fifty pounds of pulpwood, or one hundred twenty-five pounds of cellulose, per acre-year. For cotton, the yield per acre-year is one hundred and fifty pounds of cellulose, for flaxstraw—one hundred pounds, and cornstalks, nearly five hundred pounds.

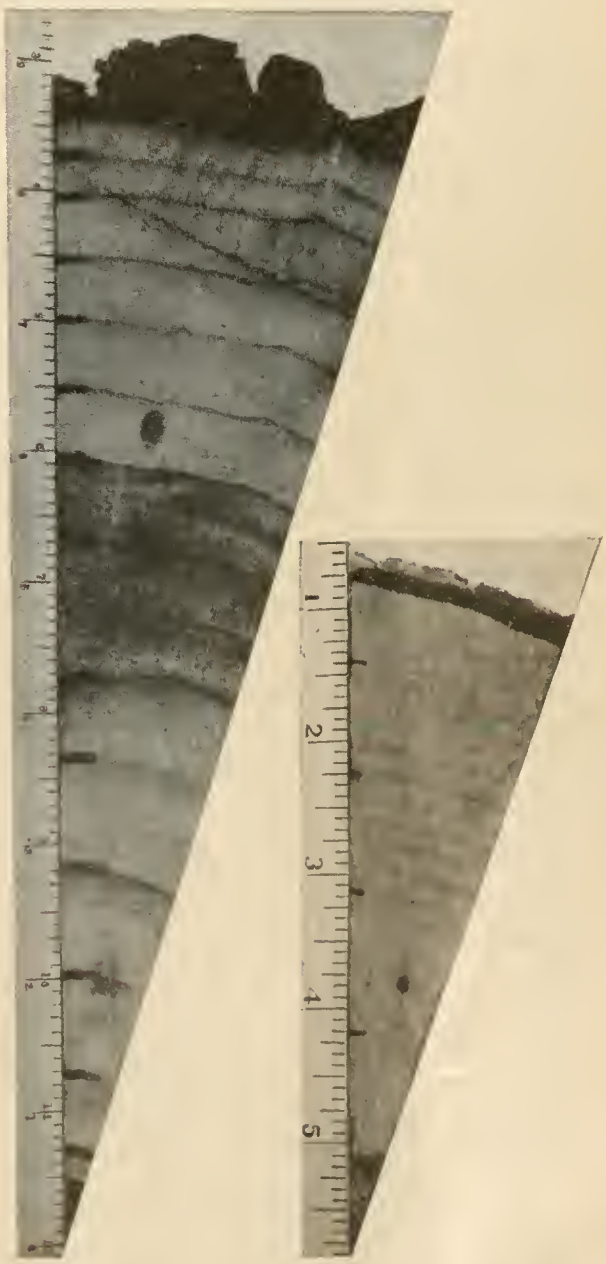
Well managed reforestation plantations of pulpwood using wild species will produce about two thousand pounds of cellulose per acre-year. From the new hybrid poplar plantations we have every reason to expect eighty cords of pulpwood per acre in twelve years, that is, an average of about sixteen thousand pounds of merchantable wood per acre-year, equivalent to eight thousand pounds of cellulose per acre-year.

Cellulose Production Per Acre-Year

Flaxstraw	100 lb.
Cotton	150 lb.
Cornstalks	500 lb.
Reforestation—Natural	125 lb.
Reforestation—Managed	2000 lb.
Reforestation—New Hybrid Poplars	8000 lb.

When trees can be grown so rapidly, they become an agricultural crop, but without the uncertainties of annual plants.

All calculations indicate that more dollars per acre-year of wood can be grown than dollars per acre-year of wheat or other common farm crops. But the whole value of reforestation is not complete with the reckoning of the dollar value of the wood grown. Such plantations protect the country from floods, and from land erosion, and tend to preserve an even climate.



Comparing width of annular rings, common poplar and mediocre hybrid. (Reduced 1/3). Best hybrids show much greater width.

New York in the Ice Age

By ALLAN BROMS

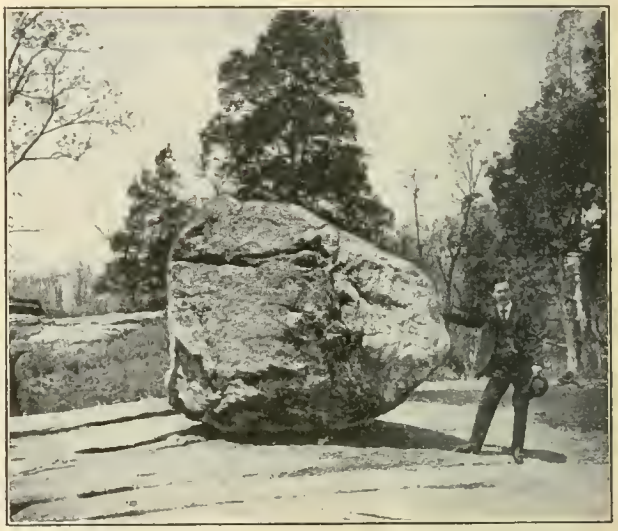
IN the Bronx Zoo stands the famous "Rocking Stone," a thirty-ton boulder perched in such nice balance that a fifty pound pressure can rock it two inches on its narrow base. It is a typical ice-borne "glacial erratic" brought and left here by the great ice sheet of the Glacial Period. Under it, the bedrock of Manhattan Schist is planed level by the overriding ice and a nearby rock knoll to the northwest has several clear grooves, one or more of which may well have been cut by this very boulder as the ice sheet, into which it was frozen, scraped it over the surface.

Elsewhere in New York are many exposures of this and other bedrocks similarly planed and scratched, and almost anywhere one can see such erratic boulders brought by the invading ice sheet. Many of these turn out to be derived from the Palisades across the Hudson River, indicating that the ice moved, not down the river valley, but southeasterly across it, a fact confirmed by the direction of the glacial scratches or striae on the bedrocks. Other erratics in the vicinity are known to have come from the Catskills and points even farther north.

These and other ice signs are to be found all over New England, Canada, the states bordering the Great Lakes and all northwestern Europe. This fact was first discovered by Louis Agassiz, who concluded that all these areas, totaling some six million square miles, were at one time covered by thick ice sheets, ever expanding from northern centers of snow accumulation. Now that we have learned to read them, these ice signs tell an eloquent story of repeated glacial invasions, all the more interesting to the amateur because they are unmistakable and furnish the essential clues to most of our surface geology.

Often these erratics are associated with a confused mixture of smaller rocks, gravel, sand and clay, all heaped together in the usual disorder of the glacial moraine, wherever the melting ice happened to dump them. Here and there, the waters of melting may have done some sorting of the gravel into irregular cross-bedded layers within the morainic confusion and spread the sands out into level outwash plains before the front of the ice. Long Island provides the perfect example. Its north half consists of terminal and retreatal moraines stretching its whole length, while the south half consists of flat outwash plains.

Because the outflowing waters were unable to transport heavy boulders, these outwash plains have no erratics whatever. But in the morainic hill belt they are everywhere, though usually buried in the earthy rubbish heap which we call glacial "drift or till." These glacial dumps are most irregular in form, being piled high into a hill here, being lacking so as to leave an isolated pond there. This was partly due to irregular melting, but also to uneven loading within and upon the glacier.

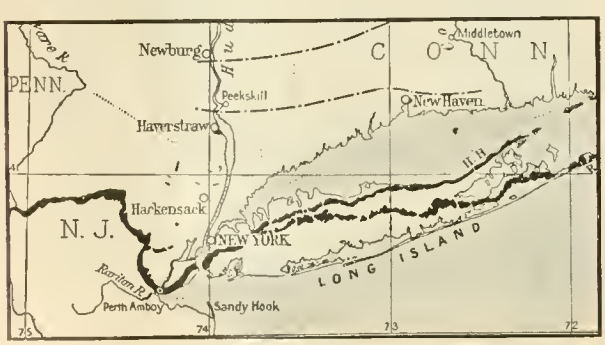


"Rocking Stone," New York Zoological Park, an ice-transported boulder on a glaciated surface.

For as the ice slowly crept southward, it had frozen on to such underlying rocks as it could loosen, carrying them along, dragging them along its bottom, grinding them together within its mass. But sooner or later it faced the onslaughts of the hot sun, turned to water, dropped everything, and ran—as water. Sometimes a great block of ice would be left buried in the moraine heap, quite deserted by the retreating ice front. When eventually the ice block melted, it left a deep hole in the hilly landscape, a typical "kettle hole."

Because they are usually buried, erratic boulders are not so conspicuous in the terminal moraine as they are over areas scoured bare by the overriding ice sheet and then covered but thinly with a scanty moraine left as the ice front rapidly retreated. In such areas there would also be a generous flow of waters from melting, tending to wash away the finer glacial materials, not overly abundant at best. Consequently, the really fewer erratics now stand out conspicuously in contrast to the nearly barren bedrocks. Up New England way they build fences of them, which also gets them out of the way of their plows.

Many bedrock masses have been smoothed and carved by the overriding ice, being left as low elongated knobs called "roche moutonnees," (rosh mootoné), a name best remembered by its French derivation, roche meaning rock, moutonnees meaning mutton, because they looked like sheep's backs. Their length is in the direction of the ice movement, the end towards the oncoming ice normally rising with a smooth upward slope,



Moraines, showing where the ice sheet halted.

while the other end is often abrupt and much broken because the ice froze to and plucked away pieces of the rock mass.

This work of planing and carving the underlying hard rocks could hardly have been done by the ice itself, it being too yielding. But the hard rocks frozen into its bottom could well serve as hob nails for the great heel of the ice. They could plane, and scratch, and even groove the bedrocks. A notable example of such grooving is found in the big slab from a Lake Erie island which is displayed at the entrance to the American Museum of Natural History. Lesser grooves are to be found in many places throughout the city, and here and there the once numerous glacial scratches. Originally, quite all the surface bedrocks were probably full of such scratches, but long exposures to weathering have destroyed them. Only where the top soil has been recently removed, do we find clear

Terminal moraine and directions of ice movement in New York vicinity during last glaciation.

glacial scratches. In the Bronx Botanical Gardens are several fine examples. In one place, the scratches cross each other at an angle, indicating that the ice movement changed direction. It is even possible to determine which were first made and which later. The Botanical Garden also furnishes examples of quite all the other signs of glacial action, even to a small glacial valley, really a big glacial groove, gouged out by the ice stream that forced its way through. Such a valley, usually much larger, is U-shaped in cross-section, for the icy mass tends to spread and fill it fully, cutting along the sides as well as center. A stream-cut valley is instead V-shaped, the water working only in the narrow central channel.

Then there are glacial pot-holes, some neat the best exposure of scratched bedrock, others along the gorge of the Bronx River. They were undoubtedly caused by the eddying waters of falls or rapids, which used rock fragments and gravels as grinding tools, swirling them round and round until holes were bored several feet deep and wide in the hard bedrocks. These, and some channels over the rocks that are plainly stream-worm, are very strangely placed, high up where, it would seem, no stream could possibly flow. But the great glacier helps us explain, for in it and under it were confining ice tunnels in which flowed swift, gravel laden streams, milling violently round each rock obstruction, with now and then a waterfall plunging down some icy crevasse. The deepest of these pot-holes is very obviously due to a waterfall; the next largest has a big tree growing in it.

These two are near the upper end of the Bronx Gorge. This gorge is obviously young, speaking geologically, for it is deep and narrow, quite unlike the valley upstream, which has had time to widen by long continued weathering and lateral erosion. Judging by the rate at which streams elsewhere are known to cut into such rocks as these, this gorge is only about 35,000 years old, which brings us back to the estimated date for the close of the Ice Age. This, and the fact that we find an old, abandoned stream valley to the west, which the railroad now follows, leads us to conclude that the ice sheet must have dumped so much rubbish into the old channel as to dam and divert the Bronx River to its present course, forcing it to cut its new gorge through the hard rocks. This conclusion is confirmed farther upstream when we come to a little round lake at an old bend in the original river channel.

More extensive and detailed studies have convinced the glacial geologists that, at the close of the Ice Age, a series of big lakes formed before the retreating ice front, covering much of the country to the south and east of Bronx Park, and filling other valleys to the west. One of these, Glacial Lake Passaic, was formed between the Watchung mountains and the ice front. With the retreat of the ice it was completely drained, but we can trace its old shore lines by the beaches at its former high levels, and the present clay beds represent its former bottom deposits.

To the eyes that see, the Bronx Botanical Garden tells another absorbing story of plant adaptations and migrations, exemplified by the fine stand of Northern Hemlocks above the gorge. These trees are native to Canada and a cooler climate, but when the cold, hard glacier crept down, these tall, proud trees marched south in wise retreat, migrating slowly by generation after generation throwing out their seeds in advance. Then when the hot sun chased the glacier out, they marched back home again but left this outpost grove of those that were lured to stay on in this garden spot.

BROMS ON THE AIR

Each Saturday evening at nine o'clock Allan Broms broadcasts popular science over station WOR, each subject, though complete in itself, being also preparation for a field trip or museum visit on the Sunday after. The June program is as follows:—

June 6, WOR, 9 P.M. THE WAYS OF THE WILD.
June 7, 10:30 A.M. Meet at Bronx Park subway entrance to N. Y. Zoological Park.

June 13, WOR, 9 P.M. THE TALE OF THE HORSE.
June 14, 1 P.M. Entrance American Museum of Natural History.

June 20, WOR, 9 P.M. THE IRON HORSE.
June 21, 2 P.M. Lobby Museum of Science and Industry, 220 E. 42nd St., New York, N. Y.

June 27, WOR, 9 P.M. RESTORING ANCIENT MAN.
June 28, 1 P.M. Entrance American Museum of Natural History.

The Saturday Radio talks by Mr. Broms will continue over WOR. Details of the correlated field trips are announced during each broadcast. Mr. Broms also broadcasts Saturdays at 7:15 P.M. over station WPAP.

The Ethics of Evolution

By MAYNARD SHIPLEY

IT is impossible to emphasize too highly the ethical value of the evolutionary concept. The Fundamentalists reiterate that "the evolutionary philosophy is brutalizing and essentially immoral." As a matter of fact, the expounders of evolution have been notable for their high moral qualities, while the worst brutes on the face of this earth never heard of evolution, much less believed in it.

MAYNARD SHIPLEY

The unscientific anti-evolutionist makes much of the phrases "struggle for existence" and "survival of the fittest," whereby the strongest live and the weakest die. But "Each for himself and the devil take the hindmost" is not, by any means, a safe maxim even in the struggle for existence. A wild horse, ass, musk-ox, elephant, etc., which would happen to vary in the direction of purely selfish individualism would soon be devoured by its natural enemies and thus leave no descendants. The same is true of the social insects, of many species of birds, and of most of the higher mammals, including man.

Man *especially* cannot live for himself alone. He could never have evolved to his present high estate on the basis of strict selfishness or individualism. The survival of the fittest in the case of many animals involves the grand and ennobling principle of *mutual aid*, as taught by Darwin and strongly emphasized by Kropotkin. Because no two individuals are exactly and in all respects alike, variation often takes place in unpredictable directions. Even in an apparently normal type of the human family anti-social individuals sometimes appear, despite the environment, or, in some cases, because of it. The secret of every moral aberration, say the geneticists, lies in the germplasm. Some investigators lay the blame on mis-education in infancy and in childhood. We even hear sometimes—from non-scientists—that a moral pervert or a victim of dementia praecox or some other malady becomes a criminal because evolution is being taught in our schools and colleges! Yet of the 125,000 or more felons in our prisons, not five per cent. were taught evolution, while from 65 to 85% have had religious training, according to official statistics.

It is precisely because I am an evolutionist that I hold such high hopes for humanity. Despite the ups and downs of human history, on the whole the human race has been growing better and better. When boys and girls learn that they were not born depraved and inherently sinful and vicious, but are the survivors of a very old race which has been, on the whole, forging onward and upward in proportion as its members have learned that virtue is its own reward, that kindness, decency and fair play alone can gain for them a high and secure place in society—when they learn that meanness, selfishness and brutality are evidences of reversion to a more primitive brute stage in the evolution of man, they will value the beauty of the ideal in conduct and do their best to make this our world a more satisfying and more delightful place in which to live, or in which, perhaps, to bring up beloved children of their own.

To learn the laws of the universe is to learn also that we must obey those laws or perish. Morality consists, in the last analysis, in obedience to nature's laws. To ignore these rules of life is to court degradation and ultimately extinction. The concept of evolution provides us with sanctions for right conduct which are based upon the unavoidable laws of nature itself. From the consequences of violation of these laws no one can escape.

We must conclude, then, that evolution not only gives a unity and direction to the study of human culture as a whole, and that modern science is unintelligible without it, but also that this discipline has great value as an educational agency.

For the student who views in imagination the long and difficult struggle of man upward through the ages there is a real sanction for right conduct as well as a penalty for maladjusted behavior. There is, moreover, ground for unfailing optimism, for confidence in a happier and nobler future for humanity. The enlightened evolutionist joyfully climbs the heights of being, eager to advance, responsive to every uplifting influence, scornful of the promptings of inherited brute emotion, spurred onward by the lure of happiness, his face ever turned toward the sunlight of a more glorious future. Behind him lies the long ancestral night of ignorance and brutality and superstition. Before him lies the pathway of perfection, the guerdon of a heaven to be realized within us.

Many causes are involved in the processes of human evolution, some of them obscure, others still unknown; but among all the factors that are clearly recognizable stands out this salient principle or law of mutal aid, of friendly co-operation as a means to higher life and fuller joy. Spreading out from the limited circle of the immediate family of parents and children, her wave of altruism and good will enlarges to encompass the tribe, the nation, and, in the not distant future, let us hope, all of the nations and all of the peoples. When we look upon human beings as the inheritors of one comparatively minute globe in the depths of boundless space, members of one great human family, it is not difficult for the evolutionist to envisage an early realization of that dream of poet and philosopher, the universal brotherhood of man.

Even were the ennobling concept of evolution not the invaluable guide that it is to further discoveries; even though it did not, as it actually does, afford us a solution of many otherwise insoluble problems, it must yet be taught in our schools for its value as an ethical incentive to the highest and noblest aspirations of the human race.

SCIENCE LEAGUE OF AMERICA

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What Is Man Becoming?

By ALES HRDLICKA
Curator of Anthropology, U. S. National Museum

NO SUBJECT has occupied attention more than the future of the individual after death; but the amount of thought given to the terrestrial future of man has been astonishingly small. Even now, thoroughly conscious as scientific workers are of human evolution in the past, they seldom attempt to picture what may happen with man during the endless stretches of time ahead of him.

Had we a perfect knowledge of the human past, our whole mental attitude towards the human problem would be altered. We should much more fully understand ourselves, could much better appreciate and weigh the changes in man now going on, and could to a considerable extent deduce validly at least the nearer future of the human species.

The essentials of the knowledge of man's past are:

Man, in origin, is not apart from but belongs to the rest of the living world.

Man has developed, in all probability gradually, from the nearest subhuman forms, and under the *exciting* influence of environmental conditions. He then progressed gradually, though doubtless not regularly or at the same rate, towards his present status. During this progress he differentiated into numerous types and races, the less successful of which have become extinct. He is still substantially attuned to Nature, though the relation is weakened through his artificialities.

Up to the end of the last main glaciation, man progressed evidently but very slowly in numbers. In general he did seemingly but slightly better than to sustain himself. His spread was slow and sparse. But after the main part of the last glacial invasion he begins to multiply much more effectively and as his numbers increase there follows gradually a spread all over the habitable earth, with an accentuated differentiation of types and races. The latter proceeded all, according to the best evidence, from but one human species, and those now living date all from the later, post-glacial, parts of human prehistory; earlier strains, such as doubtless there were, can no more be traced among living men.

The main phenomena of human differentiation or "evolution" throughout the past, are on one hand a progressive mentality, on the other hand a progressive physical adaptation and eventual refinement. It is a wonderful and, in general, sustained progress from a more-or-less ape-like precursor to the highest type of man and woman of today.

When we impersonally observe the present, it is seen, notwithstanding its great complexities, to be merely a developing continuation of the past. Man is still, it appears, as plastic in body and mind as he ever was, probably even more so; he is still struggling with environment, though controlling it more and more every day; and he still changes.

He lives longer and better. He suffers less physically. Elimination of the less fit has largely changed to elimination of the unfit only. Less mother's and child's hard labor, more and better food, with exercise, sport and personal hygiene, are bringing about an increase in stature of civilized man, while less use of the jaws and muscles of mastication is reducing the teeth, the jaws, the breadth, protrusion and massiveness of the face. The head in general among the cultured is becoming slightly broader and larger, the skull and facial bones thinner, the physiognomy more lively and expressive.

The features, the hands, the feet, are becoming more refined, and general beauty is on the increase, in both men and women. The sensory organs and centers, particularly those of sight, hearing and taste, are evidently growing more effective as well as more resistant. And there is unquestionable advance in civilized man of mental effectiveness and mental endowments. Records in endurance and in accomplishments are ever being surpassed, and in modern commerce, industry, finance, science, applied arts, bring to light mental giant after giant.

Those and other progressive changes in the cultured man of the present are resulting, it is true, in various weakenings and consequent disorders. The hair, especially in the men, is being lost prematurely; the teeth are weakened in resistance, there are troubles of eruption, and some of the dental units tend to disappear. The facial changes, while favoring a greater variety and higher range of the voice, lead often to disturbing irregularities of the nasal structures and palate. The weakenings through less use of the feet and other organs (appendix, muscles, etc.) result in difficulties, even dangers. Great mental application favors digestive and other disorders; etc. But all these disadvantages are being checked by new adaptations and have but a moderate effect of retardation on the general evolutionary progress of civilized man.

Such, in high lights, was man's past and such is his present, in evolution. The important problem before us is what, on the basis of what preceded and what is now observable, may with approximate safety be expected for the future.

In general man's past and present permit the statement that he is not yet perceptibly near the end of his evolution, and the prediction that, according to all indications, he will for long yet keep on progressing in adaptation, refinement and differentiation. But this applies only to the main stream of humanity, the civilized man. The rest will be more or less brought along, or left behind.

The progress of the advancing parts of the race may be foreseen to be essentially towards ever greater mental efficiency and potentiality. The further mental developments may be expected to be attended by an additional increase in brain size; but this gross increase will be of but moderate proportions. The main changes will be in the internal organization of the brains, in greater blood-supply, greater general effectiveness.

The skull will in all probability be still thinner than it is today. And the skull may on the whole be expected to grow fuller laterally and also antero-posteriorly, due to developments in the directions of least resistance. The hair of the head, the indications are, will probably be further weakened. The stature promises generally to be even somewhat higher than today among the best nourished and least repressed groups.

The face will, it may be expected, proceed slowly in refinement and handsomeness and character. This partly through in-

*Proceedings of American Phylosophical Society

The Amateur Scientist

A Monthly Feature

WHAT SHARP EYES SEE

By PAULINE H. DEDERER

Through nature education, the joys of hunting with a camera have been extolled as a substitute for hunting with a gun. Even without gun or camera, nature hunting may have its lucky shots if our mind's eyes can be trained in marksmanship, alert to see, understand and appreciate the country we are in, and its plant and animal life.

A rotting log in the woodland is one of the best examples of a self-sufficient community, where each creature is solving somehow the problem of how to make a living. Here are damp moulds, fungi and lichens, food for animal life, among which we find abundantly the little gray pill-bug, humble cousin of the lobster, centipedes untroubled by the thought "to know which leg comes after which," soft white grubs of beetles, caterpillars of moths, spider eggs in white silken blankets, soft-shelled snails trailing a shining path of slime. On these small fry the birds feed, and so we find a chain of nature or a web of life as Darwin called it, which forms the fabric of the community life.

Good examples of fresh water associations of animals may be found among the inhabitants of swamps, bogs and pools. Take a pool or small pond in a meadow. Here is a miniature world in the universe of the countryside—and how may the inhabitants of its depths speculate upon the "nature of the world, and of bugs!" In this small world we find several different levels of society. The lowest stratum consists of small creatures which burrow in the mud. Scoop up a netful of mud and you will find in the early spring, tadpoles of frogs, nymphs of dragon-flies with huge trap-door jaws. Here they swim about in company with thread-like worms, microscopic protozoa, small insects and large predatory water beetles, water spiders and snails which attach themselves to submerged water plants. Near the surface of the water, amusing waterboatmen ply their feathery oars, and the little back-swimmers dart about in apparent frenzy. Mosquitoes leave the cast-off garments of babyhood upon the surface of the pool, and wing their way. Red-spotted newts poke their noses up for air, and green frogs sit serenely at the margin. Darting above them all are the winged insects, notably the dragon flies, which had their birth in the pool below, and the birds that alight on overhanging branches.

The greatest interest of a small pond or marsh in the spring is, to my mind, in the various stages one may find of the development of several kinds of amphibia (frogs, toads and salamanders). The eggs are familiar bunches of brown or blackish spheres enclosed in a mass or masses of transparent jelly. You may identify the species with a Palmer chart which explains the distinguishing characteristics of the eggs, and the time of year they are laid. In our eastern woods we may see at the breeding season, which

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tensifying intelligent sexual selection, partly through further reduction of the bony parts consequent upon diminished mastication, and partly through the further development of the frontal portion of the skull. The eyes will, it is plain, be rather deeper set, the nose prominent and rather narrow, the mouth still smaller, the chin more prominent, the jaws even more moderate and less regular, the teeth tending to smaller, diminished mostly in number, even less regular than now in eruption and position, and even less resistant. The future of the beard is uncertain, but no such weakening as with the hair of the head is as yet observable.

The body will tend to slenderness in youth, the breasts towards small, the pelvis parts but little affected, the lower limbs towards long, the upper rather towards short, the hands and feet towards narrower, the fingers and toes towards more slender, with the fifth toe probably further diminishing.

As to the internal organs, the only more plainly foreshadowed probabilities are a further weakening and diminution of the appendix, and a shortening, with diminution in capacity, of the intestines. As food may safely be expected to continually be more refined and made more digestible, the necessity of a spacious large intestine will diminish in proportion.

Physiologically, the tendencies indicate a rather more rapid than slower pulse and respiration with rather slightly increased than decreased temperature—in other words a livelier, rather than more sluggish, metabolism. But substantial changes in these as well as in other organic functions are not to be anticipated for many millenniums; these functions are too firmly established.

So much for normal conditions. There is, regrettably, also the debit side to be considered. Man has ever paid for his advance, is paying now, and will pay in the future. Functional disorders, digestive, secretive, eliminative, disorders of sleep and sexual, can not but multiply with the increasing stresses, exertions and absorptions. Mental derangements will probably be more frequent. Destructive diseases such as diabetes, and various skin troubles, will probably increase until thoroughly understood and hindered. The teeth, the mouth, the nose, the eyes and ears, will ever call for an increased attention. The feet will trouble.

Childbirth will not be easier nor less painful; though assistance will equally rise in effectiveness. Due to prolonged life, heart troubles, apoplexies, cancer, and senile weaknesses of all sorts, will tend to be more common, until mastered by medicine. All this, with many abnormal social factors, will retard but not stop man's progress, for the indications are that he will rise equal to all his growing needs as they develop and begin to hurt.

There is no life-danger to humankind to be apprehended on these scores. If there is a danger to human future, it lies in the birth rate of the torch-bearers. Already now the birth rate in the families of the most intellectual is unsatisfactory.

To try to fathom what will happen with man in the distant future would be to lose ourselves in unwarranted speculation. Only a few facts seem certain. As man will advance in knowledge, so he will advance in the understanding of what is truly advantageous and what truly disadvantageous to him, which will make it easier for him to follow the right road. He will advance in the control of nature, which will aid him greatly in shaping his own destinies. And he will ever more understand disease with its antidotes and immunization. With these gains in perception and power, notwithstanding the many difficulties in the way and the many less fit that must be left behind, a long human progress appears assured.

lasts from March through June, abundant specimens of the wood frog, green frog, leopard frog, pickerel frog, and the tiny tree toad an inch long, that inflates its throat like an amber bubble and gives its clear shrill "peep." The garden toad also joins this gathering, for practically all amphibians frequent the water to lay their eggs. Salamanders also issue from their hiding places under damp stones, and crawl to the water's edge on the same errand. Here in the warmth of the spring sun, the egg masses pursue their course of development—mysterious even though all its history may be known—into the tadpole stage characteristics of the species, and finally attain the adult form.

Next in the list of animal habitants let us take land associations. Some of these include animals of the surface ground and animals living on vegetation. As you walk through the woods you may be passing by some black-and-white or yellow-spotted salamander hidden under a stone, or a tiny red-backed salamander concealed under the bark of a dead tree. Many forms of life can be brought to light by turning over stones and stripping bark from dead trees. Your eyes will have to be sharp to find signs of life upon bushes and trees. Look for cocoons of moths, hanging like dead leaves upon twigs. Examine green leaves curled over to form the covering for some insect eggs. You may find a "walking-stick" which looks like a twig until you see it move or discover dull-colored moths resting upon the bark of trees, perfectly camouflaged. Look for cast-off skins of cicadas (incorrectly called locusts) still adhering to the tree trunks by ghostly claws, showing a split down the back through which the iridescent adult burst its prison.

Sharp eyes will find these things. It is something at least to have found your quarry, but don't stop there. Find out something about its life history. Can you follow it from the cradle to the grave? How does it make its living? Do you see any special value in any of its parts for the kind of life it has to lead? You will find zest now in planning a small nature library to aid you in your quest. Charts and pamphlets published by various nature organizations are helpful and inexpensive. Use these at home to round out your study. Observation may reveal what an animal does but not what it is.

Best Evolution Pamphlet

The clearest, simplest explanation of EVOLUTION is "The Proofs of Evolution" by Henshaw Ward, excellent for beginners and opponents. Sent postpaid for 10c; 20 for $1.

Question Box

Answers by ALLAN BROMS, *unless otherwise credited*

Q.— How do such meteorites as those at the American Museum of Natural History originate, and how do you explain that peculiar crystal structure inside them? F. P. J.

A.— These meteorites, as you know, have fallen upon the earth from outer space. Most "shooting stars" are much smaller, mere grains of meteoric sand that burn into ashes from the friction of the air as they rush through it at speeds up to 44 miles per second. The large meteors can reach earth without burning all up because the heat of friction on their surfaces does not have time to strike into the interior, but merely fuses a thin outer shell. So this heat cannot help us explain the internal crystalline structure.

T. C. Chamberlin, in his "The Two Solar Families", has given us a reasonable answer to both your questions. It is well known that the "shooting star" meteors, and the comets with which they are associated, travel in long elliptical orbits that take them alternately out into the cold depths of space and then close to the hot sun. They stay long out in the distant zone of darkness and cold where the sun's gravitational pull is very feeble. So the fine dust specks and larger meteoric grains have a chance to gather into loose clumps under their own mutual gravitational pulls, even though these be very weak. Their collisions are gentle, for the motions are very slow, both in their orbits about the sun and in their falls towards each other . Besides they are out there in the feeding grounds a long time before they return to the vicinity of the sun. But as they head sunward they fall, slowly at first, then faster and faster, until they reach enormous velocities in passing the sun. They might well be broken up and dissipated by the melting heat of the sun, but if they are largely metallic, they instead fuse and hang together. This probably explains why most large meteorites are metallic, composed of an iron-nickel alloy, with only a mixture of stony matter. Such molten metallic masses, as they slowly cool through the months of their retreat into cold outer space, stay together and tend to crystalize, explaining the characteristic interior structure, which when polished and etched by acid, reveals the formerly mysterious Widmanstatten figures to which you refer. Of course, each time they pass through the outer feeding grounds, they will add to their size, each sunward trip fusing the loose matter so accumulated into the main meteoric mass.

* * *

Q.— Why are crocodile tears? J. C.

A.— Of course, I realize that you are "kidding" me, but my comeback is to give a sensible anwser to a foolish question. Tears came into the lives of crocodiles, other reptiles and all other higher back-boned land animals because they serve a useful purpose, give advantage in the struggle for existence. For crocodiles, even though they spend so much time in the water, are land animals in their physical structure. They breathe with lungs all through life, have legs for walking on land all through life, and have eyes fitted to land life all through life. The emphasis on "all through life" is to distinguish them from the amphibians, the frogs, newts and salamanders, who start off as water-dwellers, breathing with fish-like gills, and who must change both structure and ways to fit them for their adult land life. Their very name, amphibians, tells that they lead this double life. Everyone knows that they represent the evolutionary transition from fishes to the land dwelling reptiles. Though the reptiles preserve many old fish and amphibian features, they are fitted only as lung-breathers and sometime land-dwellers. They always, for instance, lay their eggs on dry land and they have tears.

Those tears are a dry-land adaptation. They substitute for the water in which the fishes live and with which they wash the dirt out of their eyes. They are never troubled, as the reptile is, by dry-land dust that gets in their eyes to torment and obscure vision. Their eyes are getting a perpetual eye-wash. When the reptiles took definitely to the land, tears came into the world, for eye-flushing purposes only. Well developed eye-lids helped too, by keeping the dust out, by loosening it mechanically. But the tears came for prosaic use not for sentimental purposes as a mere eye-wash. The crocodile has no use for sentiment in his life.

It would interfere with his method of getting a living. But he does have use for tears. Of course, this does not explain the origin of that saying about "crocodile tears", but that happens to be another story.

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Fundamentalist Follies

In this Monthly Feature EDWIN TENNEY BREWSTER *will refute all fundamentalist objections to evolution.*

SCIENCE AND THE LEGAL MIND

The Theory of Evolution, by Nathan G. Moore (Lakeside Press, Chicago) has just come to its third edition, the first only two years old. Written, as the title page informs us, "from a lawyer's point of view," the Fundamentalist press has proclaimed it with one voice as at once the exposure and the refutation of the errors and the fallacies and illogical vagaries of evolutionary science. Here, at last, is a trained legal mind, that can put two and two together, cross-examine testimony, point out contradiction and fraud—in, short, reason!

One reads as far as page fourteen, and encounters "There are five hundred thousand classified forms of mammalian life and two hundred and fifty thousand of plant life, says Prof. Kellogg (Evolution, p. 8) "

It sounds fishy! Mammalian species are some what rare birds. Most of us, running over those we know in our own districts, can name something like fifty. Adding all we have seen in museums and read about, will double the number. As a matter of fact, there really are rather less than one percent of the "five hundred thousand classified forms of mammalian life" which Lawyer Moore will have us suppose that Vernon L. Kellogg thinks there are.

Yet, curiously enough, our learned brother, further along in his book (p. 282) quotes—this time correctly—another zoologist, "In round numbers, there are . . . only 36,000 known species of vertebrates." So we have Lawyer Moore quoting an authority on one page for 500,000 mammals; and on another page, another authority for 36,000 vertebrates! Can it be that this champion of the Lord and smiter of evolutionary Philistines does not know what either a vertebrate or mammal really is?

The plot thickens. One turns to Kellogg's original text (Evolution, p. 8) and there reads, "We have found and described and clasified and named about 500,000 living kinds of animals and 250,000 kinds of living plants."

So it wasn't "mammals" after all that Kellogg really said, but "animals." But "animal" and "mammal" do sound a good deal alike. An author might easily substitute one for the other—especially if he hadn't much idea what either word means!

Our fundamentalist limb of the law, in short, quotes a perfectly plain sentence out of one zoologist; and in it, along with other glaring inaccuracies, manages to substitute "mammal" for "animal." Quoting correctly another zoologist, he gives his readers to understand that there are fourteen times as many mammals in the world as there are vertebrates. He puts these absurdities in his manuscript; which manuscript he revises the customary number of times. Then he corrects his proof, supposedly twice. Finally, he reads the printed work—a weakness that no author escapes. Later he prepares a second edition. After this, comes a third.

All three editions go out for review. Fundamentalist editors laud the volumes to the skies. Fundamentalist preachers tap them freely for sermons. Fundamentalist parents purchase largely hoping to get ahead of their offspring who are taking high school zoology under sinful pedagogs who believe in evolution.

And nobody notices anything wrong! Moreover, the work has in abundance "more of same"—and some of them are even more obvious and even more absurd than the one selected here as a sample of Fundamentalist science. But no Fundamentalist has spotted any of them, else the author would have been informed of his blunders and corrected them. For Fundamentalist reviewers and editors and clergymen and parents, as for Fundamentalist lawyers, mammals and vertebrates are all "science falsely so-called!" So far as they are not still another invention of Evolutionists they are too nearly the same thing for a Fundamentalist to trouble himself over distinctions!

What could proclaim with louder voice than the Fundamentalist's own, the mental level of anti-evolutionism?

BOOKS

THE STORY OF EVOLUTION. By Benjamin C. Gruenberg. D. Van Nostrand Co., N. Y. $4.00.

FROM DUST TO LIFE. By Burton P. Thom. Dutton & Co., N. Y. $5.00.

The title of Gruenberg's latest book is a misnomer, for he discusses the Factors of Evolution rather than its Story. Aside from this and his old disposition to placate the Fundamentalists, he does a fine job of clear and interesting popular writing of up-to-date accuracy. He is to be commended for speaking up more courageously than heretofore and for the way he has covered and condensed a vast subject without loss in either clearness or accuracy. The many illustrations maintain the same high standard.

Thom really writes the Story of Evolution, the whole of it at that, from the very origin of things to Man's evolving mind. He makes a vivid story of it too, almost romantic at times without loss to its science. Here also, the clear style is ably abetted by numerous fine drawings. As a whole, the story is panoramic in its scope, but there is interesting detail and incident throughout. On the scientific side only one exception need be taken. Since the preparation of his opening chapter, our rapidly developing science of sub-atomic physics has greatly modified the account here presented. Otherwise, the book is a remarkable review of our evolutionary past.

ALLAN BROMS.

THE CASE AGAINST EVOLUTION. By George Barry O'Toole, Ph.D., S.T.D. 408 pp. Macmillan, N. Y.

Professor O'Toole differs from all the other authors of recent books opposing evolution, (except L. T. More) in having a scientific training. He differs from all the others in having some real acquaintance with Biology. It is, therefore, interesting to see what sort of case he offers.

There is a specious appearance of fairness in his foreword, in the statement that he is presenting only the negative evidence, as the evidence in favor of evolution is fully presented elsewhere. It is soon evident, however that he is adopting the usual special pleading employed by other authors of this type, but in a more subtle form. For example, he demands the experimental production of a new species under controlled conditions, but arbitrarily defines a species as one existing in nature, which is hardly compatible with production in a laboratory (p. 4-5.). He entirely ignores the new forms, essentially of specific grade, which have been produced under controlled conditions within the last fifteen years, or those developed under domestication. Again he garbles the meaning of quotations as where he quotes Bather (p. 3) to imply that phyletic series are now discredited, when the actual meaning is that they are steadily becoming more closely linked and more exactly demonstrable.

Mendel, a fellow priest, is deservedly praised, but there is no hint of the fact that the field which he founded, Genetics, is responsible for the appearance, in the laboratory, of distinct physiological species. Muller has proved that it is not true that *all* mutations are disadvantageous (p. 44). Hence the argument that mutations can have no evolutionary significance falls of its own weight.

The treatment of the evidence from fossils (chapter III) is particularly unsatisfactory. Quotations, taken out of context, are used to support labored misinterpretations (especially pages 76-96). The existence of any positive evidence contradicting Professor O'Toole's thesis is ignored.

Professor O'Toole is sufficiently acquainted with the field of Biology not to take the late Alfred McCann's book, "God or Gorilla" very seriously. However, he is so innocent of any knowledge of Geology that he takes Price's fantastic catastrophism seriously, and he bases a part of his argument on Price's ideas, which, in turn, are based on a purely reading knowledge of Geology (p. 96-112). He follows Price in denying the existence of overthrusts, which can be demonstrated, in the field, to any averagely intelligent high school student. (It is amusing that Price has apparently never looked at any of the phenomena, in the field, about which he writes so glibly). On pages 111-112 and 335, Professor O'Toole kindly tells us which of the results of Geology he is willing to accept, on a provisional basis.

The chapters on "The Origin of the Human Soul" may interest the pious reader, as may the afterword. As they are essentially theological, rather than scientific, they do not require discussion here. The chapter on "The Origin of the Human Body" is based on the same old methods the juxtaposition of apparently contradictory quotations from various authors, removed from their context, the suppression of contradictory evidence, and strained conclusions drawn on purely dialectic basis. One is grateful, however, for his logical statement (p. 268-9): "the only choice which sound logic can sanction is between fixism and a thorough going system of transformism, which does not exempt the human body from the scope of the evolutionary explanation." With this statement we can have no quarrel.

Prof. O'Toole, while not a scientist (since he has not produced original work) has a respectable training quite enough to be held fully responsible for what he says and how he says it. It is regrettable, but true, that while on a more intellectual plane, his book is as worthless as those of Bryan, LeBuffe, McCann, Price, Riley and Williams. It is interesting, however, to see that an intelligent and fairly well-trained individual, such as Professor O'Toole, can only produce so feeble an effort to disprove the fact of evolution.

HORACE ELMER WOOD, 2ND.

PARADE OF THE LIVING. By John Hodgdon Bradley, Jr. Coward McCann, N. Y. 308 pp. $3.00.

This is the best-written survey of the history of life which has appeared during the present revival of popularized science. Dr. Bradley is a skilled maker of striking phrases; a stylist whose methods are those which most readily give dead bones life, and even endow them with speech. No one can complain that *Parade of the Living* is a tedious book, and its vivacity seems to meet material reward. To the paleontologist, however, it suffers somewhat from that very quality. The progress of life has been slow and blundering; the parade which Dr. Bradley shows us so breathlessly has failed to include a new phylum in five hundred million years, while most of its participants have died by the way. There were gaudy costumes upon its bands and queer assemblages in its cages; but the bands were out of step and the procession demoralized. Dr. Bradley's present tense and active voice obscure the confusion, and indicate, now and then, that the beasts themselves willed to change.

Yet it is doutful that these defects will make much difference to the non-paleontologic reader. He may, however, justly complain at the absence of pictures, which either forces him to rely on word impressions or to consult such a book as Lull's *Organic Evolution*. The chances are that he'll do the former, and thereby lose some of the reality which Dr. Bradley has tried (so successfully) to give his narrative.

CARROLL LANE FENTON.

Funnymentals

"Such things as railroads and telegraphs are impossibilities and rank infidelity. There is nothing in the Word of God about them. If God had designed that His intelligent creatures should travel at the frightful speed of fifteen miles an hour, by steam, he would have clearly foretold through his holy prophets. It is a device of Satan to lead immortal souls down to hell." Christian School Board, Lancaster, O., 1828, quoted by Sprading in Science Versus Dogma.

Evolution is "a theory that will completely undermine our present civilization, sweep away all present standards of morality and turn the world back into barbarism, and all founded on pure speculation." W. G. Bennett in May, 1931, "Fax."

"It (Noah's flood), is the only explanation of those great bone deposits that characterize the eastern and western shores of North America, and are found in heaps in other portions of the earth. Animals do not die in huddles, nor do they crawl to some graveyard and lay themselves upon the bones of their ancestors to breathe their last, but such a flood as is recorded in Genesis, drowning the animals of the earth, would by the tidal and translation waves thereof, tend to pile them in exactly such ricks, on ocean shore lines, with the final recession of waters to sea beds . . . .

"It would wipe from the earth those great saurians that feasted upon its luxurious vegetation, and pile them up in heaps of the dead, exactly as the Wyoming excavations discovered them a few years since, burying them in the rock of the plateau, 7,000 feet above sea level, since their great hulks would not tend to drift away with the receding waves as did those of lesser animal life . . . . The flood is the solitary explanation of all these facts." Rev. W. B. Riley, Christian Fundamentalist, May, 1931.

SEND MORE FUNNYMENTALS

Readers are invited to help secure ammunition for the Funnymentals column. If you have any fundamentalist statements, either written or oral, that you think worthy of being reprinted under FUNNYMENTALS, send them along. But be sure you quote ACCURATELY, and give exact authority.

New Address: 175 Varick St., N. Y. C.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912, of Evolution, published monthly at New York, N. Y., for April 1, 1931.

State of New York, County of New York, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared L. E. Katterfeld, who, having been duly sworn according to law, deposes and says that he is the Managing Editor of the Evolution, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are: Publisher, Evolution Publishing Corporation, 344 E. 16th St., New York, N. Y.; Editor, none; Managing Editor, L. E. Katterfeld, 344 E. 16th St., New York, N. Y.; Business Managers, none.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address as well as those of each individual member must be given).

Evolution Publishing Corp., N. Y.; Allan Broms, New York, N. Y.; Martin Dewey, New York, N. Y.; Wm. King Gregory, New York, N. Y.; L. E. Katterfeld, New York, N. Y.; M. Mark, Swavzee, Ind.; A. Nielen, Cincinnatti, Ohio: Frank A. Sieverman, New York, N. Y.; Elihu Thomson, Swampscott, Mass.; Morris Weinberg, New York, N. Y.

3. That the known bondholders, mortgagees, and other security holders owning ot holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.) None.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

L. E. KATTERFELD, *Managing Editor.*

Sworn to and subscribed before me this 15th day of April 1931.

CHARLES S. HEFTER, *Notary Public.*
My commission expires March 30, 1933.

MAROONED!

On Friday evening, May 29, 1931, the International Convention of the World's Christian Fundamentals Association, in Philadelphia again upheld "Noah's Flood versus the Darwin Philosophy!"

THE GREAT EVOLUTION DEBATE

Between Prof. Joseph McCabe and Rev. W. B. Riley, which Riley would not publish in his fundamentalist magazine, appeared in full in three issues of EVOLUTION. Postpaid, 25c; ten or more 15c. Sells like hot cakes at meetings. We'll mail the three numbers containing this debate to any list of names for 15c a set. Fire a Broadside at your friends.

THE TEST

"Do you look to authority for proof, or to proof for authority?"

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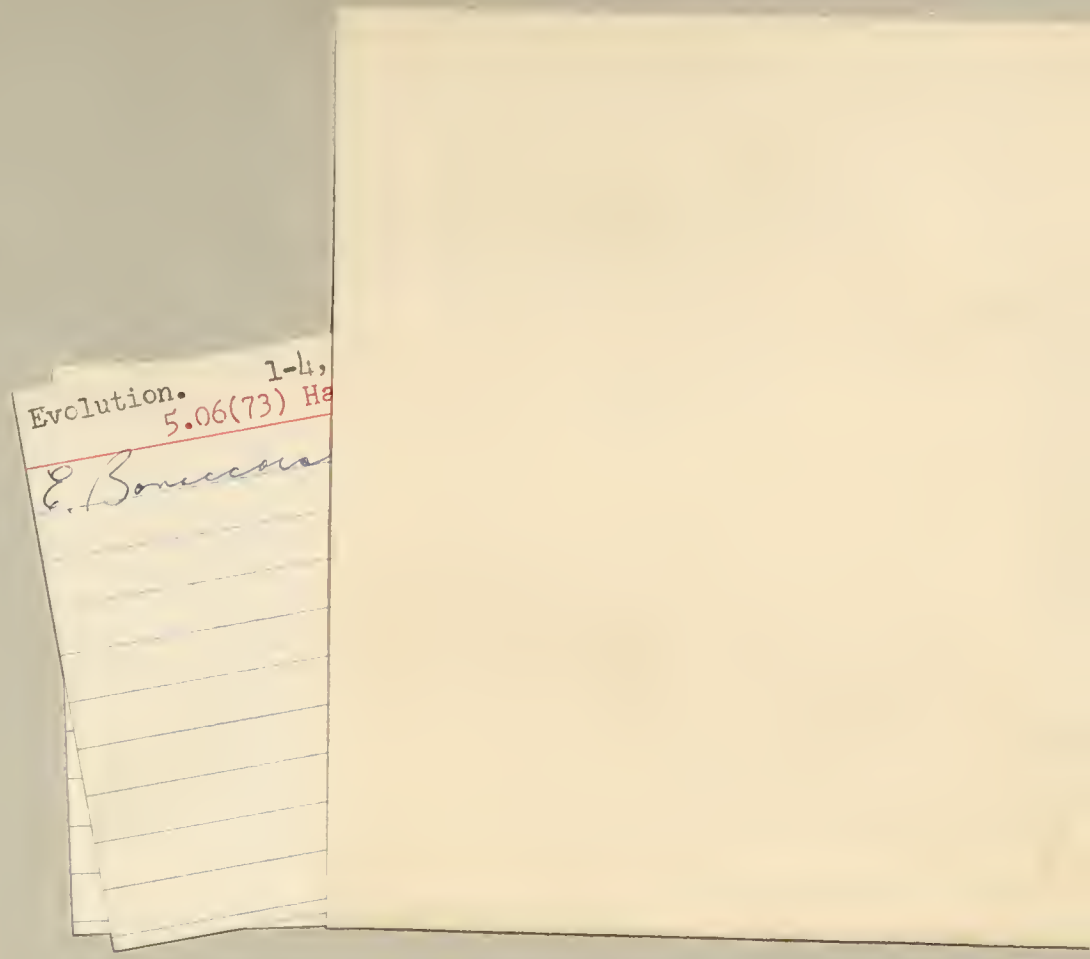

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